Frequency of Serum Low-Density Lipoprotein Cholesterol Measurement and Frequency of Results ≤100 mg/dl Among Patients Who Had Coronary Events (Northwest VA Network Study)*

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This population-based, cross-sectional analysis targeted all veterans with coronary heart disease (CHD) who were active patients in primary care or cardiology clinics in the Veterans Health Administration Northwest Network from July 1998 to June 1999. We report guideline compliance rates, including whether low-density lipoprotein (LDL) was measured, and if measured, whether the LDL was ≤100 mg/dl. In addition, we utilized multivariate logistic regression to determine patient characteristics associated with LDL measurements and levels. Of 13,891 active patients with CHD, 5,552 (40.0%) did not have a current LDL measurement. Of those with LDL measurements, 39.1% were at the LDL goal of ≤100 mg/dl, whereas 26.5% had LDL ≥130 mg/dl. Male gender, younger age, history of angioplasty or coronary artery bypass grafting, current hypertension, diabetes mellitus, and angina pectoris were associated with increased likelihood of LDL measurement. Older age and current diabetes and angina were associated with increased likelihood of LDL being ≤100 mg/dl, if measured. Although these rates of guideline adherence in the CHD population compare well to previously published results, they continue to be unacceptably low for optimal clinical outcomes. Attention to both LDL measurement and treatment (if elevated) is warranted.

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According to the revised National Cholesterol Education Program (NCEP) Adult Treatment Panel II guidelines released in 1993, lipid levels should be aggressively treated in patients with coronary heart disease (CHD).[1] In 1995, 90% of physicians reported that they were aware of the NCEP guidelines and almost 90% said they used them in their practice.[2] Nonetheless, studies examining cholesterol management in patients with CHD through 1997 found that patients were being undertreated.[3–9] More recent studies have been needed to examine current NCEP guideline adherence for secondary prevention among broad-based clinical populations. We undertook a cross-sectional analysis of cholesterol management among patients with CHD in the Northwest Network of the Veterans Health Administration (VA). Our goals were to describe current secondary prevention practices and compare them to NCEP recommended guidelines.

METHODS

The Quality Enhancement Research Initiative in Ischemic Heart Disease (IHD-QUERI) is a national VA initiative to improve outcomes of veterans with CHD by improving compliance with national treatment guidelines. As part of IHD-QUERI, we extracted data on all active primary care and cardiology patients with CHD from the VA Northwest Network Data Warehouse—a relational database containing data from the clinical information systems of each of the 8 VA medical facilities in the Network—including patient demographics, outpatient and inpatient utilization and diagnoses, pharmacy records, and laboratory data.

The index date for this study was June 30, 1999. Patients were eligible if they were active patients in primary care or cardiology clinics in the Northwest Network and if they had known CHD. The Northwest Network includes VA facilities in Anchorage, Alaska, Boise, Idaho, Portland, Roseburg, and White City, Oregon, and Seattle, Tacoma, and Walla Walla, Washington. Active patients were defined as being alive on June 30, 1999, with ≥1 primary care or cardiology clinic visit during the 12 months ending June 30, 1999, and with ≥1 primary care or cardiol-

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ogy clinic visit during the 12 months ending June 30, 1998. Using these criteria, 69,999 patients were determined to be active primary care or cardiology clinic patients. Patients were defined as having CHD if they met ≥1 of the following criteria: (1) percutaneous transluminal coronary angioplasty or coronary artery bypass graft surgery performed at any VA facility; (2) a hospital discharge diagnosis of myocardial infarction (MI) or unstable angina (International Classification of Diseases-9th edition [ICD-9] codes 410 to 411); (3) a hospital discharge diagnosis of previous MI, stable angina, or other chronic CHD (ICD-9 codes 412 to 414); (4) ≥1 outpatient visit at a Northwest VA facility with an CHD diagnosis (ICD-9 codes 410 to 414) in the 12 months ending June 30, 1999 and ≥3 prescriptions filled for nitrate antianginal medications; (5) a recorded history of coronary angioplasty or coronary bypass surgery (ICD-9 codes V45.81, V45.82).

Although the algorithm was considered face-valid and 59% of the patients met multiple criteria, we also validated the selection algorithm by reviewing randomly selected charts of 306 patients who met only a single criterion. Of these "single-criterion" individuals, 84% had documentation supporting a diagnosis of ischemic heart disease in the electronic medical record.

Using the above criteria, 13,891 of the 69,999 active patients were determined to have CHD and comprised the study population for our cross-sectional analyses. This group encompassed the entire population of active patients with CHD in the Northwest Network.

Lipid levels measured for inpatients or outpatients ≥15 months before the June 30, 1999 index date were included in the cross-sectional analysis as "current" lipid measurements. Although the NCEP guidelines recommend yearly LDL cholesterol measurements, the 15-month cutoff was chosen to account for practicalities of clinical care. If several LDL cholesterol measurements were recorded during this period, the most recent measurement was used in the analysis. One Northwest VA facility did not have LDL cholesterol as an orderable laboratory test until October 1, 1998. Until this date, providers used the Friedewald formula to calculate LDL from total cholesterol, high-density lipoprotein cholesterol, and triglyceride levels. For this facility, calculated LDL values were used before October 1, 1998 whenever values for these 3 lipid components were available. LDL cholesterol was categorized as ≤100, 101 to 129, 130 to 159, and ≥160 mg/dl. LDL cholesterol ≤100 mg/dl was considered the LDL goal level.

Lipid-lowering drug use was determined using VA outpatient pharmacy prescription data. Current lipid-lowering drug users were defined as those who received a lipid-lowering drug ≤12 months before June 30, 1999. If the drug type or dose varied across the 12 months, the most recent dose was used. Daily dose was calculated from the product strength, quantity dispensed, and days supply. Dose range was defined according to manufacturer's recommendations, incorporating any age-specific guidelines. "Low dose" was defined as the recommended starting dose, "high dose" was defined as the maximum recommended dose, and "medium dose" was defined as all intermediate doses. Drugs with a single recommended dose, such as cerivastatin, were labeled as "medium dose." Patients taking multiple lipid-lowering drugs concurrently were defined as "multidrug" users.

We reviewed inpatient discharge diagnoses and procedures from January 1, 1986 to June 30, 1999 and current-year outpatient diagnoses from July 1, 1998 to June 30, 1999. We defined history of MI as any inpatient or outpatient ICD-9 diagnosis code of 410 to 412. History of coronary bypass or coronary angioplasty was defined as a procedure code in the inpatient files or an inpatient or outpatient diagnosis code V45.82 or V45.81, respectively. Current angina was defined as ICD-9 diagnosis codes 411.1, 411.81, 411.89, or 413 to 413.9 from the current-year outpatient diagnosis file. Similarly, current diabetes and hypertension were defined as ICD-9 diagnosis codes 250 and 401 to 405.99, respectively, from the current-year outpatient diagnosis file. Obesity was defined as a body mass index of ≥27.8 kg/m^2 for men or ≥27.3 kg/m^2 for women between July 1, 1998 and June 30, 1999.[10] Current smokers were defined as patients who received an outpatient diagnosis of tobacco use disorder (ICD-9 code 305.1) between July 1, 1998 and June 30, 1999 or who were coded as current smoker in the VA Health Factor table during this time. This table contains results from a variety of preventive care interventions.

Multivariate logistic regression was used to determine patient characteristics associated with an LDL cholesterol measurement for all patients, and characteristics associated with being at the LDL goal of ≤100 mg/dl for patients who had an LDL measurement. Variables were selected based on a priori hypotheses and univariate analyses. The final selection of variables in the model was based on overall model fit and the statistical significance of the variable under consideration for inclusion in the model. Statistical analyses were performed using SPSS (Version 9.0) and Stata (Release 6, Stata Corporation, College Station, Texas).

The study design was approved by the Human Subjects Division at the University of Washington and by the Human Subjects Subcommittee of the Research and Development Committee at each VA facility involved in the study.

RESULTS

Table 1 shows the demographic characteristics of the 13,891 patients who met diagnostic criteria for CHD in the Northwest VA region. Patients were typically elderly, white males. Almost a third (37.6%) of patients had a history of MI, whereas 11.7% had undergone coronary angioplasty and 31.7% had undergone coronary bypass graft surgery. Risk factor levels were high, with 56.9% having current hypertension and 30.9% having current diabetes. Among those whose LDL was measured during the study months, the mean measured LDL cholesterol was

TABLE 1 Demographic Characteristics

	CHD Patients (n = 13,891)
Gender	
Men	13,591 (97.8%)
Women	300 (2.2%)
Mean age (yrs) (SD)	68.4 (10.5%)
Race/ethnicity	
White	11,709 (84.3%)
African-American	426 (3.1%)
Hispanic	163 (1.2%)
Other or unknown	1,593 (11.5%)
Marital status	
Married	8,014 (57.7%)
Never married	763 (5.5%)
Separated or divorced	3,643 (26.2%)
Widowed	1,451 (10.4%)
Unknown	20 (0.1%)
Hospital location	
Anchorage	637 (4.6%)
Boise	1,632 (11.7%)
Portland	3,336 (24.0%)
Puget Sound	3,244 (23.4%)
Roseburg	1,718 (12.4%)
Spokane	1,449 (10.4%)
Walla Walla	1,139 (8.2%)
White City	736 (5.3%)
Mean no. of annual clinic visits per patient* (SD)	13.6 (22.5)
History of MI	5,217 (37.6%)
Coronary angioplasty	1,621 (11.7%)
Coronary bypass	4,401 (31.7%)
Either	5,440 (39.2%)
Current	
Hypertension	7,909 (56.9%)
Angina pectoris†	3,163 (22.8%)
Diabetes mellitus	4,297 (30.9%)
Obesity‡	4,878 (55.5%)
Cigarette smoker	2,753 (19.9%)
Mean total cholesterol‖ (SD)	190.2 (40.4)
LDL cholesterol¶ (SD)	112.0 (33.4)
HDL cholesterol# (SD)	41.7 (12.4)
Triglyceride (SD)**	209.1 (168.3)
Patients taking lipid-lowering drugs	6,923 (49.8%)

*Outpatient primary care or cardiology clinic visits between July 1, 1998 and June 30, 1999.

†Outpatient or inpatient ICD-9 diagnosis of angina or unstable angina between July 1, 1998 and June 30, 1999.

‡Body mass index ≥27.8 kg/m^2 for men or ≥27.3 kg/m^2 for women among the 8,795 patients with height and weight measured between July 1, 1998 and June 30, 1999.

‖Mean total cholesterol level for the 10,904 patients with levels measured between April 1, 1998 and June 30, 1999.

¶Mean LDL cholesterol for the 8,339 patients with levels measured or calculable between April 1, 1998 and June 30, 1999.

#Mean high-density cholesterol level for the 8,777 patients with levels measured between April 1, 1998 and June 30, 1999.

**Mean triglyceride levels for the 8,860 patients with levels measured between April 1, 1998 and June 30, 1999.

TABLE 2 Measured Low-Density Lipoprotein (LDL) Cholesterol Levels (n = 13,891)*

LDL Levels (mg/dl)	CHD Patients
≤100	3,263 (23.5%)
101–129	2,870 (20.6%)
130–159	1,541 (11.1%)
≥160	665 (4.8%)
Not measured	5,552 (40.0%)
Total	13,891 (100%)

*Based on LDL cholesterol measurements between April 1, 1998 and June 30, 1999. For patients with multiple LDL cholesterol values during this period, the most recent LDL level was reported.

TABLE 3 Predictors of Guideline-Concordant Treatment Elements

~Variable	LDL Cholesterol Measured*† (n = 13,891)	LDL Cholesterol ≤100 mg/dl, If Measured (n = 8,339)
	Odds Ratios (95% CI)	
Men	1.37 (1.08–1.74)	0.90 (0.65–1.25)
Age‡	0.76 (0.73–0.78)	1.10 (1.05–1.15)
History of MI	1.01 (0.94–1.09)	1.03 (0.93–1.13)
History of coronary angioplasty	1.37 (1.22–1.55)	1.14 (0.99–1.30)
History of coronary bypass	1.52 (1.40–1.64)	1.08 (0.99–1.20)
Current hypertension	1.70 (1.58–1.82)	1.07 (0.98–1.18)
Current diabetes mellitus	1.30 (1.20–1.40)	1.52 (1.38–1.67)
Current cigarette smoker	1.10 (0.99–1.21)	0.96 (0.85–1.08)
Current angina pectoris‖	1.67 (1.52–1.83)	1.26 (1.13–1.39)

*Results of multivariate logistic regression analysis with LDL measurement as the dependent variable and the above predictors as covariates. The model was also adjusted for race, VA facility, and the number of primary care or cardiology clinic visits between July 1, 1998 and June 30, 1999.

†Based on LDL cholesterol measurements between April 1, 1998 and June 30, 1999.

‡Odds ratio for each 10-year increase in age.

‖Inpatient or outpatient diagnosis of stable or unstable angina between July 1, 1998 and June 30, 1999.

112.0 mg/dl, which is above the NCEP recommended goal of ≤100 mg/dl.

The distribution of LDL levels from the 15 study months is listed in Table 2. Of the 13,891 patients with CHD, 5,552 (40.0%) did not have a LDL cholesterol measurement within the 15 study months. Less than a quarter (23.5%) of the population was at the NCEP LDL cholesterol goal of ≤100 mg/dl, whereas 15.9% were ≥130 mg/dl. Of those with LDL measurements, 39.1% were at the LDL cholesterol goal of ≤100 mg/dl and 26.5% had LDL cholesterol ≥130 mg/dl.

The first column of Table 3 provides the results of multivariate logistic regression to determine predictors of having an LDL measurement during the 15 months of the study. In addition to the covariates in the table, the regression models were adjusted for race, VA facility, and the number of primary care or cardiology clinic visits during the study months. Male gender, history of coronary angioplasty, history of coronary bypass, current hypertension, current diabetes, and current angina had significant positive associations with LDL measurement. Increasing age had a significant negative association with LDL measurement. Including age in the regression model as an indicator variable showed that patients 65 to 74 years old and patients ≥75 years old were significantly less likely to undergo LDL measurement than patients <65 years old (odds ratio 0.85, 95% confidence interval 0.78 to 0.93 and odds ratio 0.49, 95% confi-

dence interval 0.44 to 0.53, respectively). White, African-American, and Hispanic patients were similarly likely to have an LDL measurement.

The second column of Table 3 shows the results of multivariate logistic regression that examined predictors of being at the LDL cholesterol goal of ≤100 mg/dl for the 8,339 patients with CHD who had a LDL cholesterol measurement during the 15 study months. Again, the regression models were adjusted for covariates in the table as well as for race, VA facility, and the number of primary care or cardiology clinic visits during the study months. Increasing age, current diabetes, and current angina had a significant positive association with being at the goal LDL. Including age in the model as an indicator variable showed that patients 65 to 74 years old and patients ≥75 years old were significantly more likely than patients <65 years old to be at LDL ≤100 mg/dl in the model (odds ratio 1.19, 95% confidence interval 1.07 to 1.33 and odds ratio 1.21, 95% confidence interval 1.08 to 1.36, respectively). White, African-American, and Hispanic patients were similarly likely to be at goal LDL.

Half of the 13,891 patients with CHD (50.2%) were not on lipid-lowering drugs, whereas 3,933 (28.3%) were on low-dose lipid-lowering drugs, 2,358 (17.0%) were on a medium dose, 518 (3.7%) were on a high dose, and 114 (0.8%) were on multiple lipid-lowering drugs. Among the 6,923 lipid-lowering drug users, the most commonly used drugs were simvastatin (80.7%), gemfibrozil (7.4%), niacin (3.8%), lovastatin (3.9%), and atorvastatin (3.5%).

DISCUSSION

This large cross-sectional study was unique in its examination of an entire population of patients with CHD. Our major finding was a low level of LDL cholesterol measurement in this high-risk population, with 40.0% of patients having no LDL measured during the preceding 15 months. Furthermore, although our CHD definition was highly specific, only 23.5% of patients were at the NCEP LDL goal of ≤100 mg/dl.

Overall, these results compare well with previous studies examining cholesterol management in patients with CHD.[3–9] Although there are differences in underlying study populations and time frames, our data seem to indicate that patients with CHD in the Northwestern VA may be receiving cholesterol management superior to other reported CHD populations: a higher proportion underwent LDL measurement, a higher proportion was at the goal LDL cholesterol, and a lower proportion had LDL cholesterol ≥130 mg/dl. Alternatively, because this study used data collected more recently, our findings may indicate a secular trend toward improved cholesterol management among all patients with CHD.

Despite the improvement over previous studies, however, this study did show persistent deficiencies in cholesterol management practices. The most striking deficiency was the large proportion of patients who did not undergo LDL cholesterol measurement. This simple yet fundamental shortcoming prevents risk stratification and presents an insurmountable barrier to guideline implementation. Identifying deficiencies in LDL measurement is a first step in assessing barriers to guideline-concordant LDL management in the VA system. In response to this study's findings, interventions are being implemented in Northwest VA facilities to increase LDL cholesterol measurement rates in patients with CHD. Additional research may examine other processes of care that promote or impede secondary prevention of CHD, such as provider acceptance of guideline LDL levels, appropriate prescribing practices, and patient compliance with recommended treatment.

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